



YOUR SOLAR HOME

Using the Sun to Heat,
Cool and Power Your Home

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Take a Solar Home Tour

On the outside this house looks like many others. Walking past it, you might not even know it was a solar home. However, once you examine the details of its design and construction, you'll see that for this house, its all about the Sun!

Solar-assisted hot water system heats water and contributes to space heating.

Solar panels on the roof generate electricity used for lighting and appliances.

Deciduous trees shade the house in summer and let the Sun's warmth heat the house in the winter when their leaves have fallen off.

Extra insulation in the roof and walls.

Front overhang shades the house from the hot summer Sun, keeping it cool.

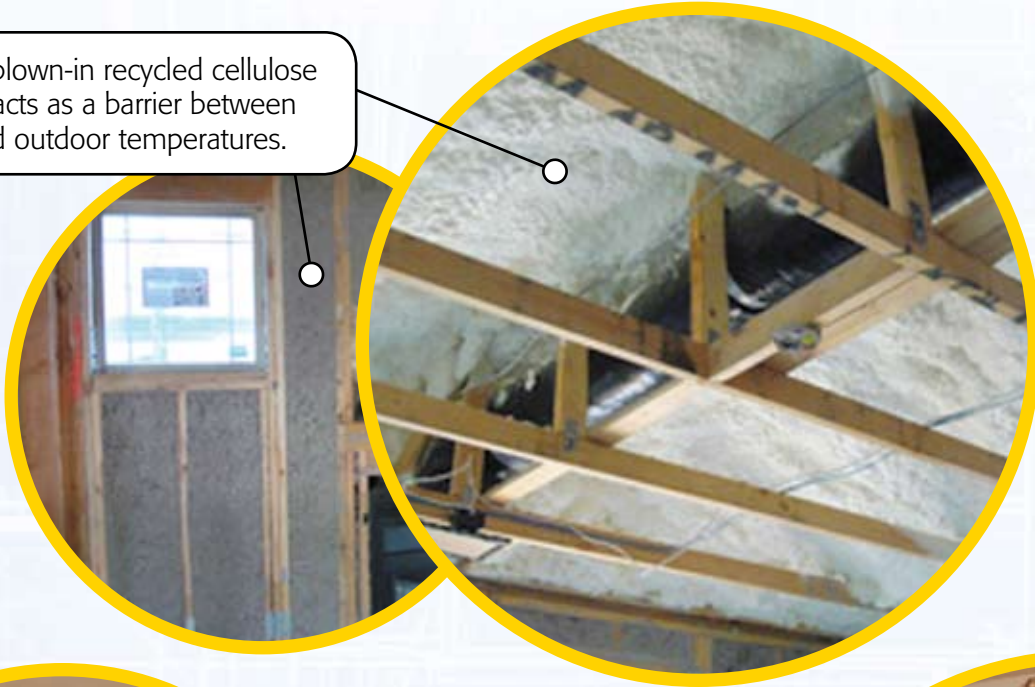
Low-e windows insulate the house from fluctuations in temperature.

South facing windows absorb the warmth of the Sun in the winter.

A backyard clothesline lets the Sun dry clothes energy free.

Drought resistant landscaping and water efficient irrigation uses less water than a lawn.

Heavy duty blown-in recycled cellulose insulation acts as a barrier between indoor and outdoor temperatures.



Some solar home features are found in homes of all varieties. How many can you find at your house?

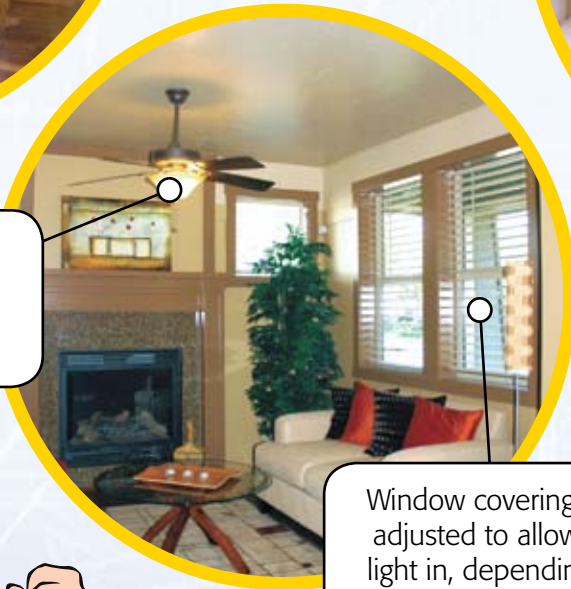
High clerestory windows let light in and keep heat out. The sunlight reflects off of the ceiling and walls illuminating the house.



Energy efficient fluorescent and LED lighting uses about 75% less energy than traditional lighting.



Ceiling fans move warm air down in the winter and provide a cooling breeze in the summer.



Window coverings can be adjusted to allow heat or light in, depending on the outside temperature.



Energy Star® refrigerator and oven use less electricity than traditional appliances.



**Now you've seen a solar home.
Follow Captain Solar and find out how it works!**

Photos courtesy of SMUD.



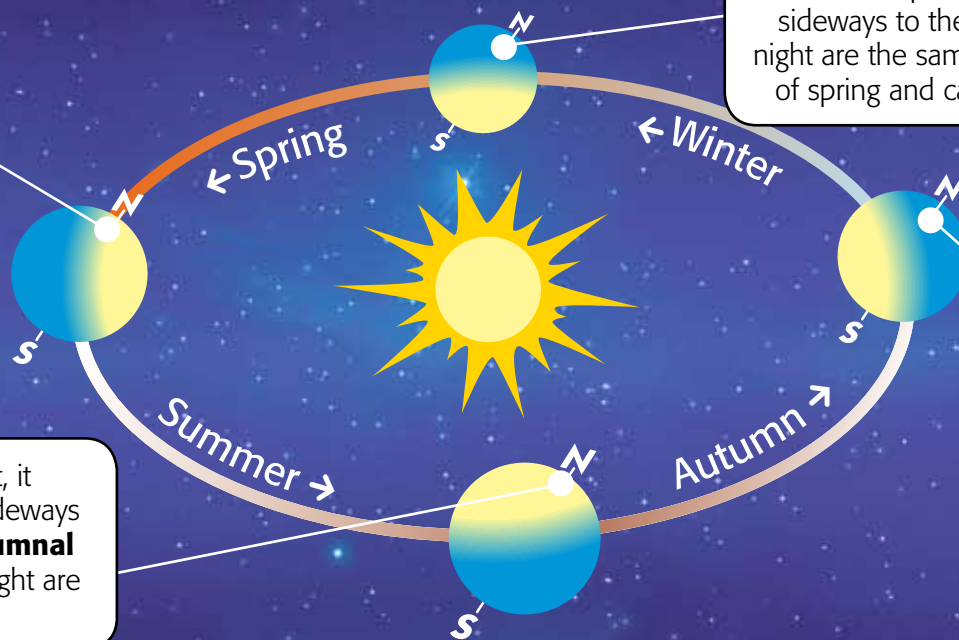
Tracking the Earth's Path

On the first day of summer, around June 21st, the northern hemisphere is tilted toward the Sun. This is called the **Summer Solstice**, and the Sun's path is higher in the sky than it is on any other day of the year. Because the Sun is in the sky for more hours, the **Summer Solstice** is also the longest day of the year.

As the Earth continues its orbit, it reaches a point where it's tilted sideways to the Sun. This is called the **Autumnal Equinox**. Both the day and the night are the same number of hours.

As the Earth continues to travel it passes another point where the axis is tilted sideways to the Sun. Once again day and night are the same length. This is the first day of spring and called the **Vernal Equinox**.

The Earth reaches the other side of the Sun on the shortest day of the year, the **Winter Solstice**. This is the first day of winter, and the northern hemisphere is tilted farthest away from the Sun.



Why are there Different Seasons?

To understand what causes the seasons of the year, remember that the Earth is always moving. It is spinning on its axis daily and also making a huge circular orbit around the Sun once a year.

At different times of the year, different hemispheres are tilted toward or away from the Sun. When an area is tilted toward the Sun, days are longer and the area receives more hours of light than when it is tilted away. These extra hours of sunlight give the Sun more time to heat the Earth. The northern hemisphere is tilted towards the Sun between June and September which is why summer is the northern hemisphere's hottest season.



Courtesy of Remun

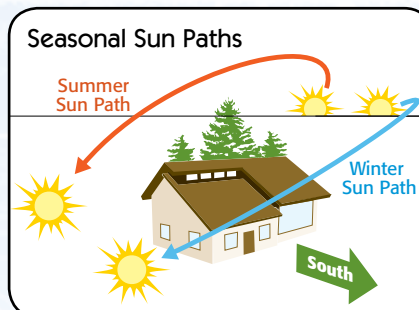
Community Planning

The suburb of Nieuwland, in Amersfoort Netherlands, is a modern example of community planning to maximize use of solar energy. Homes were built to face south allowing their rooftop solar modules to get optimum Sun exposure regardless of the season.

Planning is Step One

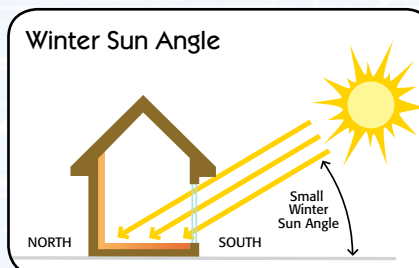
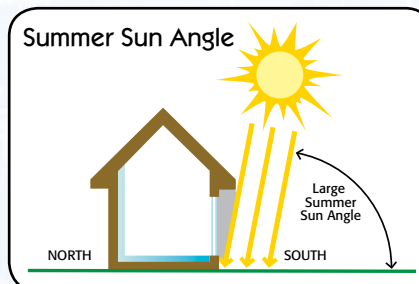
The first step in designing a solar or energy efficient home is a solar site evaluation. Before plans are begun, architects and home builders evaluate the annual path of the Sun in relation to the specific construction site. That knowledge is useful when making decisions such as the building orientation, floor plan, roof design, overhangs, window placement, building materials and landscaping.

The Sun's path also effects the optimal size, location and position of a solar electric (photovoltaic) system for maximum exposure to sunlight. The more sunlight a solar module gets, the more electricity it will generate.



The Sun's path in the sky changes as the Earth travels around the Sun. During the summer months, the Sun is high in the sky. In the winter, the Sun crosses much lower in the sky.

Houses facing south can stay cooler in the summer by using window overhangs to shield them from direct sunlight. In the winter, when the Sun is lower in the sky, the windows let in the heat from the solar rays.





Heating Things Up



Understanding Heat

To heat our homes with sunlight in the winter and keep them cool in the summer, we need to understand what heat is, and how it is transferred from one object to another.

Heat is a form of energy that moves in three different ways: **radiation, convection & conduction**. Heat always flows from warmer areas to cooler areas. It only stops flowing when both areas reach the same temperature. Using the principles of heat transfer allows us to heat objects, cool them, or keep their temperature static.

Principle #1: Radiation

The direct transfer of heat by electromagnetic waves.

There are many types of radiation. Light, heat and radio waves are just a few of the many kinds of radiation we use in our daily lives.

Radiation transfers heat between objects that are not touching. Sunlight is a form of radiation that transfers energy from the Sun through the vacuum of space.

Principle #2: Conduction

The movement of heat through direct contact.

Conduction is the transfer of heat by direct contact. Heat moves by conduction when two objects of different temperatures are touching each other. The warmer object will conduct heat to the cooler object until both reach the same temperature. Conduction is also the movement of heat *within* a solid object.

Substances that transfer heat well are called **conductors**. Metals, especially copper and aluminum transfer heat easily and are good conductors. Still air and gases are poor conductors.

Principle #3: Convection

The movement of heat through gases & liquids.

Heat also travels through the air as moving currents. The faster the air is moving, the more quickly it can transfer heat by convection. The air in contact with the heat source absorbs heat, expands and rises. Cooler air below moves in to take the place of the rising warm air. Liquids behave similarly when heated by convection, the warm liquid rises being replaced by the cooler liquid.

Slow moving or still air is a poor conductor, transfers heat very slowly and can even act as insulation.

Insulation

Substances that slow down convection, conduction and radiation.

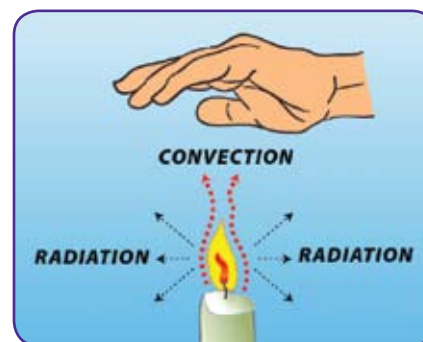
Many materials, such as Styrofoam and leather, are poor conductors and transfer heat slowly. Poor conductors are also called **insulators**. Since still air is an insulator, anytime we can trap air to keep it from moving, it provides insulation from heat transfer.

Knowing how heat moves is important when learning to design a solar home.

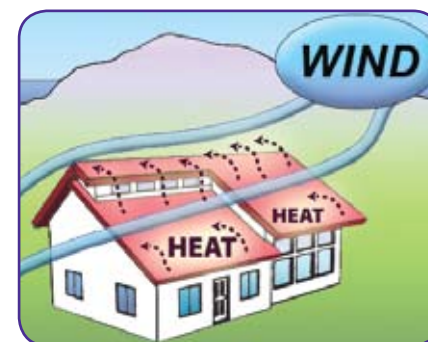


Radiation: When sunlight shines on an object, it's either absorbed into the object or bounces off. Black surfaces absorb almost all of the sunlight that falls on them. When light is absorbed into an object it turns into heat. White and mirror-like surfaces reflect light and heat.

Conduction: When an egg cooks in a frying pan, the cooler egg is in direct contact with the hot surface of the pan, and absorbs heat by conduction.



Radiation & Convection: Hold your hand in *front* of a candle and you can feel the heat radiating to you. But put your hand *above* the candle and it quickly gets very hot. This extra heat is being transferred to your hand by convection.



Heat Loss by Convection: When wind blows across the roof, a house can lose a lot of heat to the wind by convection; the faster the wind is moving, the more heat it pulls from the roof.



Insulation: The down stuffing in a jacket or sleeping bag has thousands of tiny spaces that trap air, and keep currents from flowing. This trapped air acts as an insulator. The thicker the layer of trapped air, the harder it is for the heat to escape.



Passive Solar Design

Passive Solar Design Features

Most homes use gas, electricity or heating oil to stay warm in the winter and keep air conditioners running in the summer. Passive solar home design applies the principles of heat transfer to keep buildings comfortable all year long with little fuel besides sunlight. How you use these principles depends on where you live. A house in the desert will focus more on summer cooling, while a house in a cold climate will need more winter warmth. Passive solar home designers work with six different principles.

1. Use sunlight for warmth.

Adding large south facing windows will automatically increase the warmth a house gains from the Sun, this is called **suntempering**. Likewise, fewer north facing windows will allow less heat to escape.

2. Use shade to stay cool.

Designing overhangs above the windows will block direct sunlight from entering the house. Strategically placed trees can also provide shade.

3. Use thermal mass.

Thermal mass is any material that is dense enough to absorb and store heat well.

4. Use insulation.

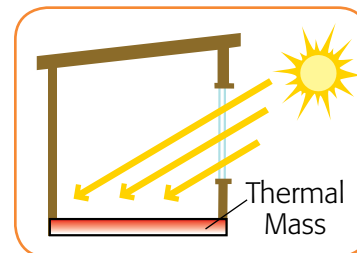
Insulating the walls and roof of the house will slow the movement of heat into or out of the house. Heat and coolth are also lost through windows. Specially coated low-e glass or double-paned windows offer more insulation than plain glass.

5. Use air flow to move hot and cold air.

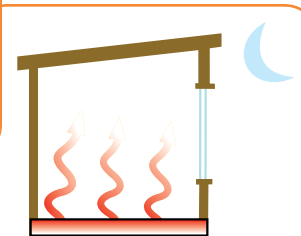
Hot air rises and cool air replaces it. High vents allow hot air to escape drawing in cool air from lower vents.

6. Use daylighting to save energy.

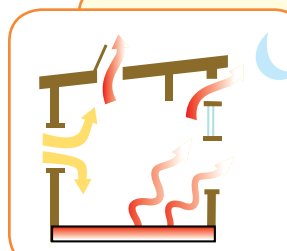
Daylighting uses indirect lighting that adds very little heat and has minimal glare.



Thermal Mass

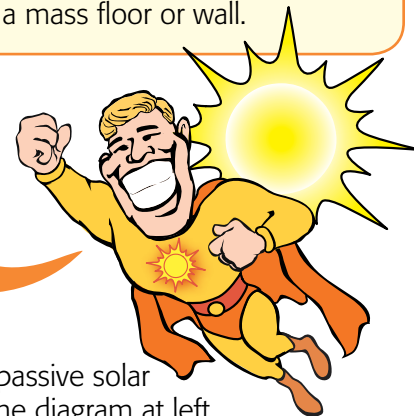


Thermal Mass: Thermal mass is a dense material like concrete or stone. Sunlight falling on thermal mass is absorbed and turns to heat. At night that heat is released keeping the house warm. This keeps the house from getting too hot or too cold.



Air Flow: The simplest way to cool a passive solar home is to open windows and vents at night. Thermal mass can then **radiate** heat to the outside. Hot air rising through ceiling vents will draw cooler air into the house. This air will absorb heat from a mass floor or wall.

How many passive solar design features can you identify below?



Identify the passive solar features in the diagram at left by writing the number next to its name. Answers on page 15.

- _____ Insulation
- _____ Thermal Mass
- _____ Daylighting
- _____ Overhangs
- _____ Shade Trees
- _____ South Facing Windows
- _____ High Vents

Solar Hot Water

Heating Water with the Sun

A key component of any solar home is its hot water heating system. The first commercial solar water heaters hit the market in 1891. They consisted of four black metal tanks placed inside a glass-covered box placed on the roof. Sun trapped by the glass heated the water inside the tanks. This system, called the Climax, had one short-coming: the tanks would cool down during the night or during cloudy weather. In 1909, William J. Bailey came up with a solution that has revolutionized solar water heating ever since. He added an insulated storage tank to the system. As the Sun heated the water in the solar collector, the hotter water would naturally rise into the storage tank where it would stay warm overnight.

However, heating tanks of water in the Sun takes a long time, often all day. Improved modern solar water systems use **solar collectors**. Instead of using tanks, solar collectors run liquid through multiple smaller tubes connected to metal fins or absorber plates. This provides more surface area to absorb sunlight and therefore heats the water more quickly.

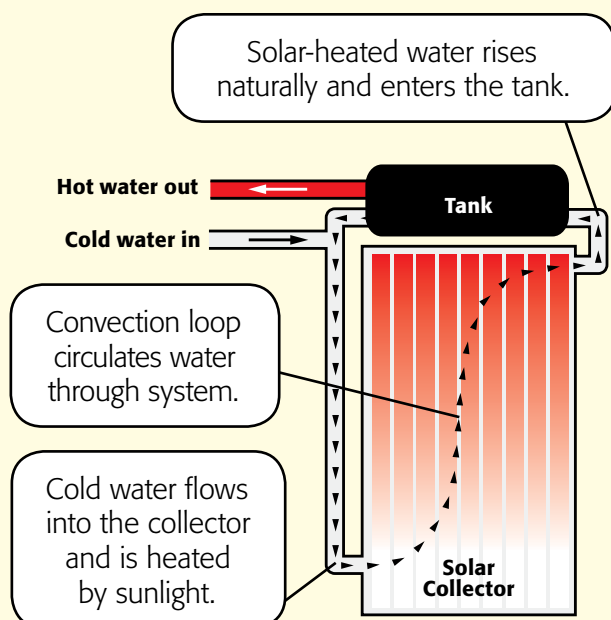


Courtesy of John Perlin and Ken Burt.

A 1892 advertisement for the Climax Solar-Water Heater. By 1900, more than 1,600 solar water heaters had been sold in southern California.

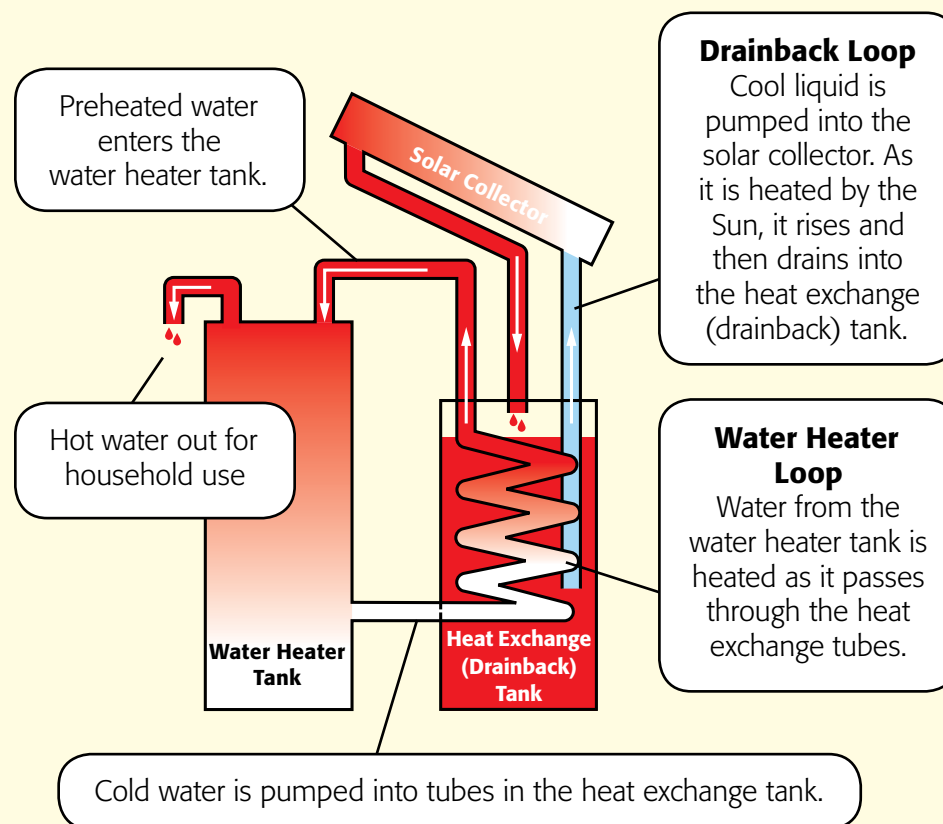
Thermosiphon System

In mild climates solar water heaters can use a **thermosiphon system** to continuously circulate and heat the water. In this system, a water tank is attached above a solar collector. As the Sun heats the water in the collector, it rises out of the top into the insulated tank. Cold water flows out of the tank to the bottom of the collector, and a convection loop forms.



Drainback System

A **drainback system** uses an electric pump to push water through a **heat exchanger**. It uses a solar collector to heat water, but instead of circulating it into the water heater tank, it is *drained back* into a separate heat exchanger tank. Water from the water heater tank is pumped through pipes within the heat exchanger and is heated before returning to storage for use.





What is Photovoltaics?

The Beginning of a Silicon Era

In 1953, the American Bell Telephone Company had a problem. Traditional dry cell batteries that worked fine in mild climates degraded too rapidly in the tropics and ceased to work when needed. The company asked its famous research arm, Bell Laboratories, to explore other freestanding sources of electricity. It assigned the task to Daryl Chapin. Chapin tested wind machines, thermoelectric generators, and steam engines. He also suggested that the investigation include solar cells, and his supervisor approved the idea.

Chapin soon teamed up with another Bell Labs researcher, Gerald Pearson who was engaged in pioneering semiconductor research with Calvin Fuller. Fuller, a chemist, had discovered how to control the introduction of the impurities necessary to transform silicon from a poor to a superior conductor of electricity. Together this team took silicon solid-state devices from their experimental stage to produce the first Photovoltaic (PV) module.

On April 25, 1954, proud Bell executives held a press conference where they impressed the media with Bell solar cells powering a radio transmitter, broadcasting voice and music. *The New York Times*, on page one of its April 26, 1954 issue, proclaimed the construction of the first PV module marked "the beginning of a new era, leading eventually to the realization of one of mankind's most cherished dreams—the harnessing of the almost limitless energy of the Sun for the uses of civilization."

pho•to•vol•ta•ics

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.



Courtesy of ARII archives.

Pearson, Chapin and Fuller in their Bell laboratory.



Courtesy of ARII archives.

The first advertisement for the Bell solar cell in August 1954.



Courtesy of John Perlin solar archives.



Courtesy of BP Solar.



Courtesy of Shell Solar.



Courtesy of NASA.



Courtesy of John Perlin solar archives.



Courtesy of Shell Solar.

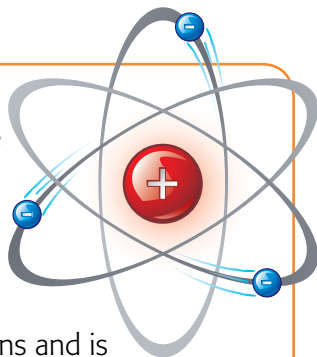
Modern PV panels at work: 1 urban safety lights; 2 Mount Everest expedition uses PV to power satellite phones, lights & laptops; 3 U.S. Coast Guard powers buoy lights & transmitters using PV; 4 portable coolers keep medications fresh in the desert; 5 giant PV panels power the International Space Station; 6 student solar boat race competition in southern California; 7 PV-powered pumps bring clean water to drought-stricken Africa; 8 domestic lighting in Mongolia.



How Photovoltaics works.

Protons and Electrons

Atoms are made up of three parts: neutrons (no charge), protons (positive charge) and electrons (negative charge). The nucleus is the center of the atom and contains protons and neutrons and is therefore positively charged. Electrons spin around the nucleus and are constantly moving. The more energy an electron has, the bigger its orbit around the nucleus. Because **opposite electrical charges attract**, electrons are pulled toward the nucleus and stay in their orbit.

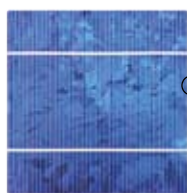


Photons

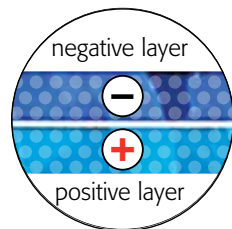
Sunlight acts like waves and also like a stream of tiny chunks, or particles of energy. These particles are called photons. Photon particles have no weight or mass and they don't have an electric charge.



Photovoltaic Cells



Silicon PV Cell



PV Cell Cross Section

Making Electricity with Photovoltaics

Turning light energy directly into electricity is called photovoltaics. The term photovoltaic combines photo, from the Greek word for light, with voltaic, named after Alessandro Volta, a pioneer in the science of electricity. The device that does this is called a photovoltaic cell, a solar cell, or a PV cell.

The Photovoltaic Effect

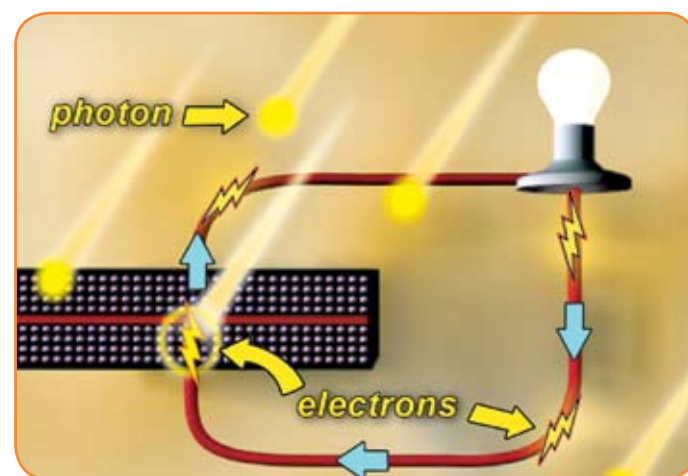
Photovoltaic cells have no moving parts, and run silently, without polluting the environment. They are made of semiconductor materials like silicon, the most common element in the Earth's crust. The silicon in PV cells is chemically treated to make a positive and a negative layer. Between these two layers an electrical field is created, similar to a battery.

When light shines on a photovoltaic cell, photons of light hit the cell and their energy is absorbed by some of the electrons in the atoms. If an electron absorbs enough energy, its orbit gets so big it breaks away from the nucleus. The electron is now a free, negatively charged particle.

These electrons will try to return to their atoms, but the design of the cell pushes them up through the negative layer. If a wire is connected between the top and bottom layers of the cell, the electrons will flow through it, and combine with atoms in the positive layer.

This flow of negatively charged electrons is called an **electrical current**. The process of photons releasing electrons is called the **photovoltaic effect**.

Electrical current is like the current of water in a stream, or water moving through a hose. It is a source of energy: the energy carried by the moving charged particles.

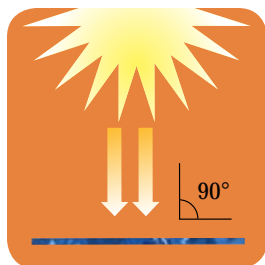


Photons release electrons from atoms to move through the wire creating electrical current or electricity.

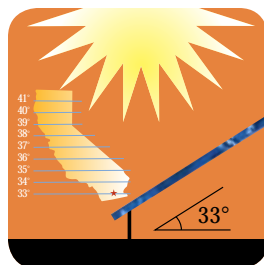
The earth receives more energy from the sun in just one hour than the world uses in a whole year.



Optimizing System Performance



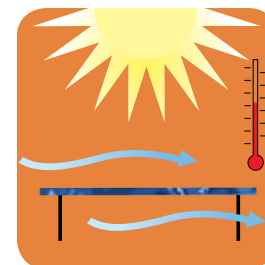
PV cells like direct sunlight, aim the cells perpendicular to the sunlight.



The fixed tilt angle of the PV array should equal the latitude of its location for best annual performance.



When PV cells are wired in a series, shading one cell restricts the electrical flow and greatly reduces output.



PV panels are less efficient when they're hot. Install them so air is free to circulate and keep them cool.



Cooking with the Sun

The Sunshine Gourmet

The first meal recorded to be cooked only with sunlight was made by Horace de Saussure in 1767. He heated soup in an insulated box topped with several layers of glass. In the 1830's, Sir John Herschel used a similar solar oven to cook a "very respectable stew of meat" at the Cape of Good Hope in South Africa.

Solar inventor Augustin Mouchot, built the precursor to the modern solar oven in 1877 for the French Foreign Legion. His oven collected solar energy with glass solar heat traps and curved mirrors. The mirror, resembling an inverted lamp shade, focused sunlight onto a glass-covered pot in which he placed food. The invention allowed soldiers and others traveling in remote fuel-short areas to eat hot food. Mouchot wrote that the solar stove provides people in Africa "with a small and simple portable stove requiring no fuel for the cooking of food." As firewood becomes scarcer in many places in the world, people are once again turning to Mouchot's template for cooking without fuel.

Using his portable solar oven, Mouchot baked a pound of bread in 45 minutes, and boiled more than two pounds of potatoes in one hour. He also cooked a roast "whose juices sizzled to the bottom" in less than half an hour.



How a Solar Oven Works

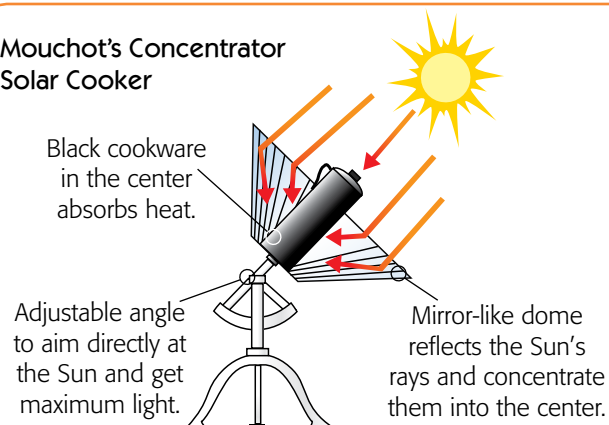
Light transfers heat through radiation. The principle of radiation is the key to understanding how a solar oven is able to generate enough heat to cook food and boil water using sunlight.

We know that when light radiates onto a surface, it is either absorbed and turns into heat (dark colored surface), reflected (light or mirror-like surface), or if the surface is transparent, light can radiate through it. So just as sunlight can radiate through liquids and gases (like water and air), it can also radiate through transparent solids such as glass.

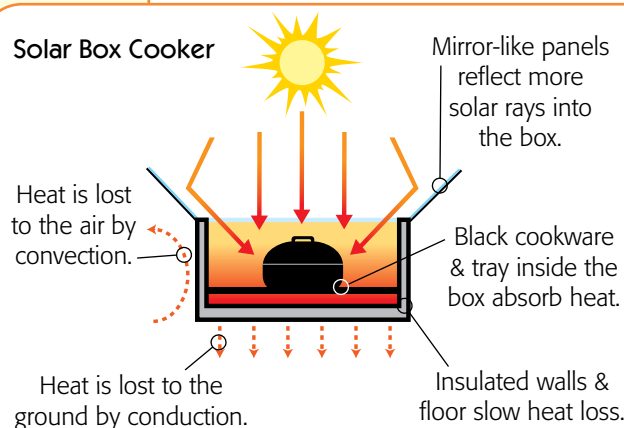
There are two basic types of solar ovens. The type of oven that Mouchot built in 1877 is called a **concentrator solar cooker**. It uses reflective panels to concentrate the Sun's rays at a dark object in the center. The dark object (a pot for example) absorbs the light which is turned into heat. Concentrator cookers can reach very high temperatures. Mouchot made one model that could melt tin, lead, and zinc in a matter of minutes.

A **solar box cooker** is another type of solar oven. A box cooker also uses reflective panels to concentrate the Sun's rays, but it also uses a transparent top and insulation. The transparent top lets sunlight in, black surfaces inside absorb the light and turn it into heat and insulation in the walls and floor keeps the heat from escaping.

Mouchot's Concentrator Solar Cooker

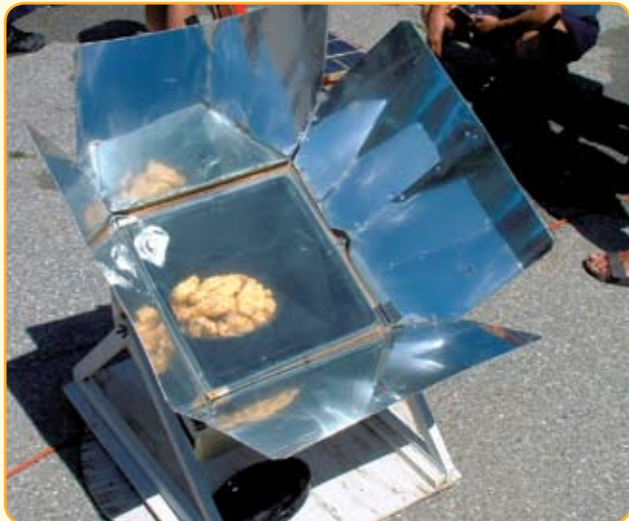


Solar Box Cooker



Learn how to make your own solar oven at www.solarcookers.org.





Remember to B-A-K-E

The basic ideas of cooking with a solar box cooker can be remembered with the word *BAKE*.

B “Bring in” as much sunlight as possible. To bring in the most sunlight, keep the cooker top facing toward the Sun. You will need to turn the box during cooking to follow the Sun. Reflectors also bring more light in. Mirrors, aluminum foil and certain types of metallic paint can be used to make reflectors.

A “Absorb” energy from sunlight. Cookers need to absorb the Sun’s energy and change visible light into heat. To do this, make sure the bottom of the box is black to absorb both visible and infrared light. Using a black pot to hold the food also helps absorb more energy.

K “Keep” the heat inside the cooker. The glass (or clear plastic) top lets sunlight in better than it lets heat out. Seal the box tightly so it will be hard for air currents to carry away heat by convection or infiltration.

If the walls are insulated, heat loss by conduction will be slowed down too. Different materials like crumpled paper, cardboard and fiberglass are used for insulation in solar cookers. These methods help the oven get hotter and cook more quickly. The food will also keep cooking if clouds block the Sun for a little while.

E “Eat & Enjoy” the Sun-cooked food!



Food for Thought

Building a solar oven out of a pizza box, is a fun way to demonstrate the power of the Sun to cook food. For many impoverished families however, a solar oven is their primary means of cooking food and sterilizing drinking water.

The United Nations’ Food and Agriculture Organization estimates that 2.4 billion people lack adequate cooking fuels. In many developing countries families may spend as much on cooking oil and wood as they do on food. Searching and gathering firewood can take up to 7 hours a day in some parts of the world. Women and children living in refugee camps can face great danger when they leave the camp to gather wood for cooking. Cooking fires also contribute to deforestation, poorer air quality and increased health problems such as lung disease, eye disease and accidental burns.

Solar ovens offer an alternative to traditional cooking fires. They provide a significant financial benefit for families previously dependent only on fuels such as oil and wood. Sun powered cooking allows families to spend more money on food, clothing and health care. Freeing their need for firewood also gives them more time to work and go to school.

Solar ovens are inexpensive, safe, easy to build and easy to use. Currently there are solar oven projects worldwide bringing impoverished people the safety and convenience of solar cooking.



Peru



Bolivia



Ethiopia

Solar ovens are an important part of daily life for residents of developing areas in Central and South America, Africa and Asia.

For more information on solar ovens visit: www.solarcookers.org.

Photos courtesy of SolarCookers International.



Fountains Run by the Sun

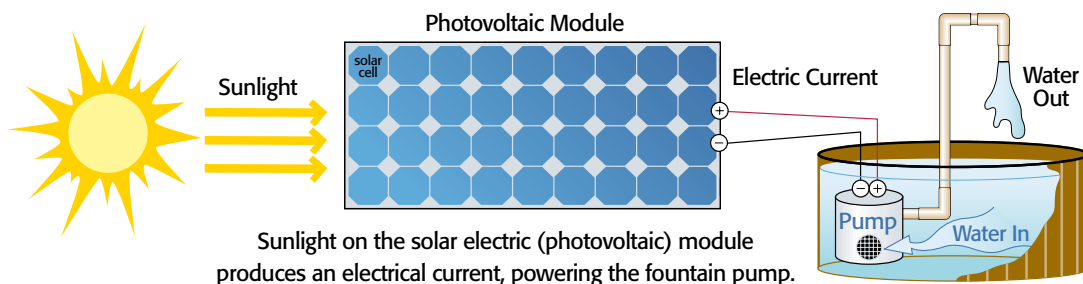
Solar Fountains

Solar fountains are fun and easy to build. Using photovoltaic modules, tubing, a simple water pump and lots of creativity, students and teachers use the power of solar generated electricity to run these works of art.

PV fountains are a wonderful addition to a school campus and a beautiful reminder of the promise and power of solar technology. They actively demonstrate the principles of solar electricity and also enrich the surrounding environment with kinetic beauty and soothing water sounds. Students see first hand the relationship of light to the electrical power by repositioning or shading the solar panel. The greater the exposure to the Sun, the faster the water flows.



How a Solar Fountain Works





Build a Model Solar Village

Building a Model Solar Village

A great way to further understand the concepts behind “your solar home” is to build a model of a solar village. When students build a model solar village it extends the lessons learned from a solar curriculum and encourages them to come together and contemplate a variety of concerns regarding **community planning** and layout.

When building a model solar village, students first design their individual solar home models using passive solar and solar electric features. They must also consider larger issues with regard to the sustainability of an entire community. Issues such as solar access (i.e. planting trees so that they do not shade your neighbors’ solar array), and planning the street grids to maximize solar access, are integrated into the process of designing and building a solar village model. The experience also leads students to ponder larger questions which their generation may face, such as how best to plan a solar community, should each house have a solar array, should one larger array power the grid, or perhaps a combination of both would be optimal.



Each model home is built to scale and students present the various solar features of their homes in an oral and written presentation.

As the solar village takes form, students work together to group their individual model homes and arrange them to maximize the collective benefits of the entire community.



It's not new!
In 400 BC, the Greeks
were positioning whole
cities to best use the
Sun's light and heat.





Solar Student Builders

Student Built Solar Homes

For nearly 20 years, as part of Randy Smith's ROP Construction Class at Brawley Union High School, students design, build, and sell a house in the local neighborhood. The proceeds go to the school and help pay for land and materials for the next project.

Since Brawley High is located in one of the sunniest corners of California, the class expressed a desire to include solar electricity on their house project, turning the rooftop into a Sun harvester. In January 2005, Mr. Smith began incorporating a week-long solar section into his class teaching his students how to wire, test, and power up a working solar system.

Since that time, each house has featured a photovoltaic electric system. The latest houses also have a solar hot water system designed and installed by the student builders. The class provides the students with the hands-on knowledge to build every aspect of a house. With the addition of the solar electric and solar hot water systems, graduates will enter the work force with an added skill in their tool belt, helping them to better compete in the emerging solar market.



Globally, PV installations reached a record high of 7.3 gigawatts in 2009. Up more than 20% over the previous year.



The Next Generation of Solar Homes

Every two years, the U.S. Department of Energy hosts the **Solar Decathlon**—a competition in which teams of college and university students compete to design, build, and demonstrate a home operated entirely by the power of the Sun. The competition premiered in 2002 and is held every two years on the National Mall in Washington D.C. Each team designs a house and is given one week to assemble it on the mall where their entry is judged and is publicly viewed.

The Solar Decathlon inspires and motivates the next generation of engineers, planners, architects and home builders to develop sustainable building strategies in all areas of home design. These young men and women not only study traditional solar designs, they forge their own innovations and technologies for the competition. New techniques for heating, cooling, lighting and running appliances are also combined with traditional solar principles in unexpected and novel ways. Many of the solar technologies and sustainable practices developed for the competition have the potential to influence home construction and design for years to come.

Solar Decathlon homes inspire young and old and demonstrate the infinite possibilities of using modern technology to harness the Sun's power. But the true victory of the Solar Decathletes is proving to governments, businesses and the public that the golden age of solar technology has arrived.



For more information about the Solar Decathlon visit www.solardecathlon.gov.



Photos courtesy of Solar Decathlon.

Solar Laundromat

Clotheslines are actually solar clothes dryers. They use no electricity, come in all shapes and sizes and can be used inside and out. Electric clothes dryers use more electricity than any other household appliance other than the refrigerator (and the refrigerator is running continuously). By using a clothesline instead of a dryer, an average American family can save more than \$120 a year in electricity costs.

Here are some additional benefits of using clotheslines:

- Line dried clothes last longer. Dryer lint is actually bits of your clothing that have disintegrated. Skipping the dryer prevents significant wear and tear.
- Line drying kills germs. The Sun's ultraviolet rays kill bacteria that may remain on clothing after washing.



- Clothes smell better. Drying clothes in the fresh air minimizes the perfume smell of many detergents and gives clothes a fresh, clean smell and feel.
- Hanging clothes is good for you. Putting clothes up and taking them off the line is a source of exercise and a good reason to get outside.

Learn more about clothesline drying. Visit: www.linedry.com.



About Solar Schoolhouse

Solar Schoolhouse is a K-12 energy education program developed by The Rarus Institute. The program uses the Sun as a starting point for teaching about energy resources, conservation, and other energy topics.

Key features of the program include:

- Modular lesson plans for integration within existing curriculum
- Teacher workshops, including the 5-day Summer Institute
- Resource kits, including: solar panels, Solar Power Monitor Kit, Solar Cell Classroom Set and Sun ovens
- *Your Solar Home Student Guidebook*, DVD, and poster
- *Teaching Solar* guidebook and DVD
- *Solar Decathlon* book and video
- Guidebooks for outdoor environmental educators and for solar pond and fountain design

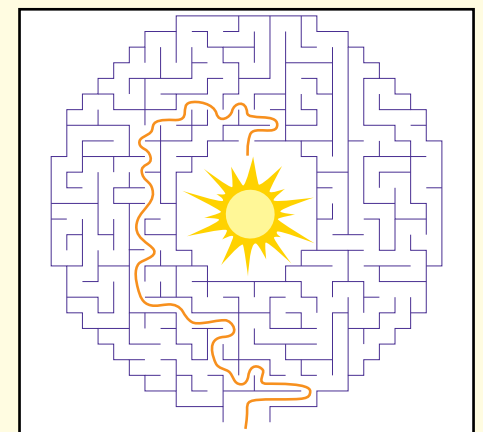


For more information, visit www.solarschoolhouse.org

Puzzle Solutions

Page 6: Insulation-4, Thermal Mass-2, Daylighting-7, Overhangs-1, Shade Trees-5, South Facing Windows-3, High Vents-6

Word Match: a-3, b-5, c-1, d-2, e-4, f-6, g-9, h-10, i-8, j-7, k-12, l-11.



Cryptogram: Here comes the Sun!

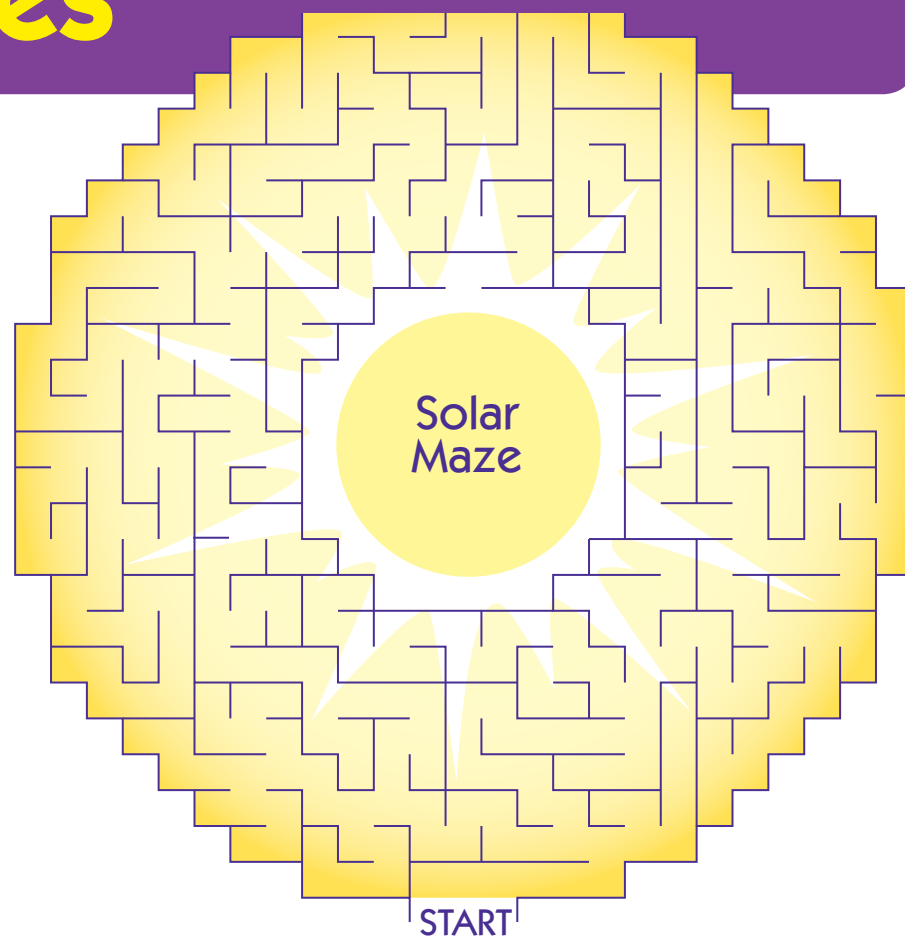


Sun and Games

Word Match

Draw a line from the word to its definition.

- | | |
|---------------------------|---|
| a. conductor | 1. Negatively charged particles in atoms. |
| b. convection | 2. A single semiconductor that converts light into electricity. |
| c. electron | 3. A substance through which heat can easily flow. |
| d. photovoltaic (PV) cell | 4. Substance that does not conduct heat well. |
| e. insulator | 5. The way heat moves through liquids and gases. |
| f. passive solar design | 6. Using the Sun to heat and cool buildings, with little or no use of machines or other fuel. |
| g. photons | 7. Solar water heating panel used to collect the Sun's heat and transfer it to a fluid. |
| h. radiation | 8. Dense material used to absorb and store heat. |
| i. thermal mass | 9. Individual particles of light or electromagnetic radiation. |
| j. solar collector | 10. The transfer of heat between objects that are not touching. |
| k. Summer Solstice | 11. The time in spring when day and night are the same length. |
| l. Vernal Equinox | 12. The time of year when the Sun's arc is highest in the sky. |



Cryptogram Puzzle

Substitute a letter for each letter below to solve the puzzle. If you think T is the substitute for A, it will be the substitute for all the A's in the puzzle.

— — — — — — — — — — — — — — — — — — — —
N G V G S I J G O B N G O Y C !

Hint: C = E

10 Easy Ways
YOU Can be an
Energy Hero!

- | | |
|---|---|
| <input type="checkbox"/> Use a solar cooker once a week or more. | <input type="checkbox"/> Use a power strip to turn off small electronics such as DVRs, video games and cable boxes. Many of these devices use electricity even when turned off. |
| <input type="checkbox"/> Take shorter showers and wash your clothes in cold water. | <input type="checkbox"/> Unplug cell phone and laptop chargers when not in use. They use electricity even if they are not charging. |
| <input type="checkbox"/> Dry your clothes outdoors on a clothesline. | <input type="checkbox"/> Walk or bike to school. |
| <input type="checkbox"/> Turn off the lights when you leave the room. | <input type="checkbox"/> Organize car pools to get to school, sports practices and games. |
| <input type="checkbox"/> Replace incandescent light bulbs with compact fluorescent bulbs, they use 75% less energy. | |
| <input type="checkbox"/> Shut down your computer and printer when idle. | |



Puzzle solutions on page 15.